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Nicholson

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(54) **TOOL CONNECTION RELEASE SYSTEM**

(71) Applicant: **ONESUBSEA IP UK LIMITED**, London (GB)

(72) Inventor: **Joseph Allan Nicholson**, Broughton in Furness (GB)

(73) Assignee: **OneSubsea IP UK Limited**, London (GB)

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E21B 17/06 (2006.01)

(52) **U.S. Cl.**
CPC ***E21B 17/06*** (2013.01)

(58) **Field of Classification Search**
CPC E21B 17/06; E21B 17/02023
See application file for complete search history.

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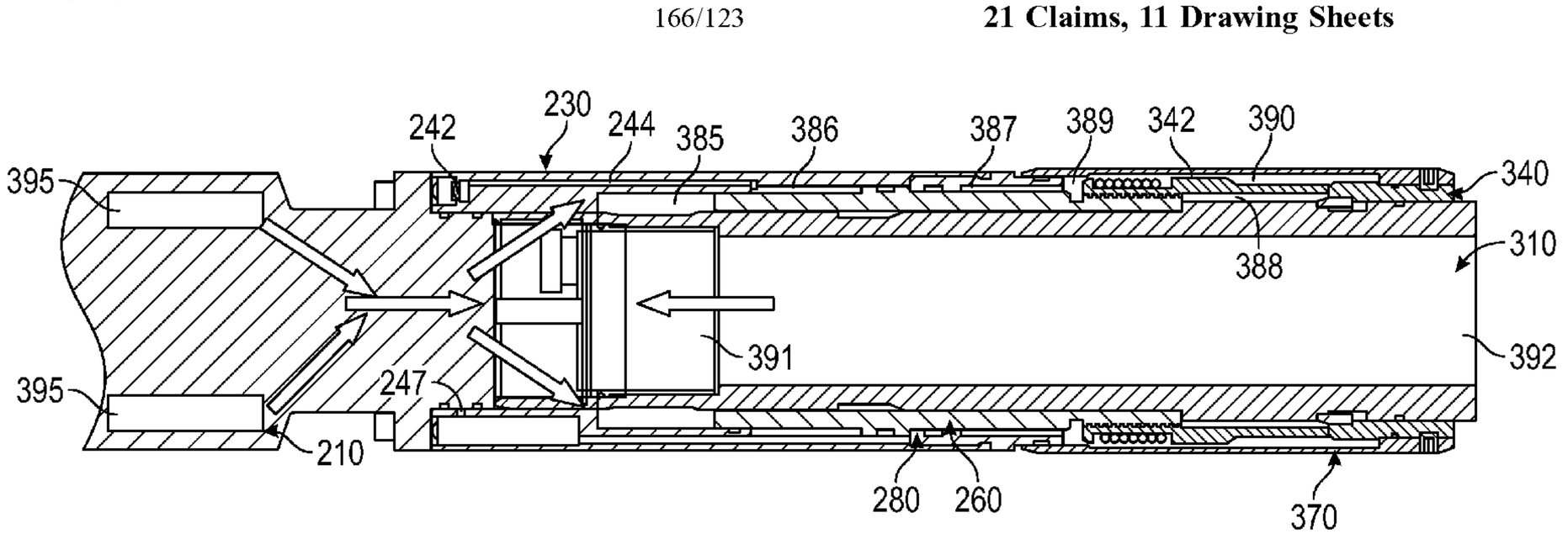
Primary Examiner — Jennifer H Gay
(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.

(57) **ABSTRACT**

A connection release system for the disconnection of various connections, such as electrical, hydraulic, optical, and/or multi-connector, to a service tool in a high pressure environment. An embodiment of the connection release system includes a first and second housing portion with a piston disposed partially within both the first and second housing portions, the piston having a plurality of threads at an exterior portion of a second end. The system further includes a plurality of fluid chambers disposed in the first housing portion, the fluid chambers are filled with fluid to pressure-balance the piston such that the addition of a pressurized fluid to the pressure-balanced piston causes the piston to move, the exterior threaded portion of the piston to disengage an interior threaded portion within the housing second portion, and allow the first housing portion to separate from the second housing portion.

21 Claims, 11 Drawing Sheets



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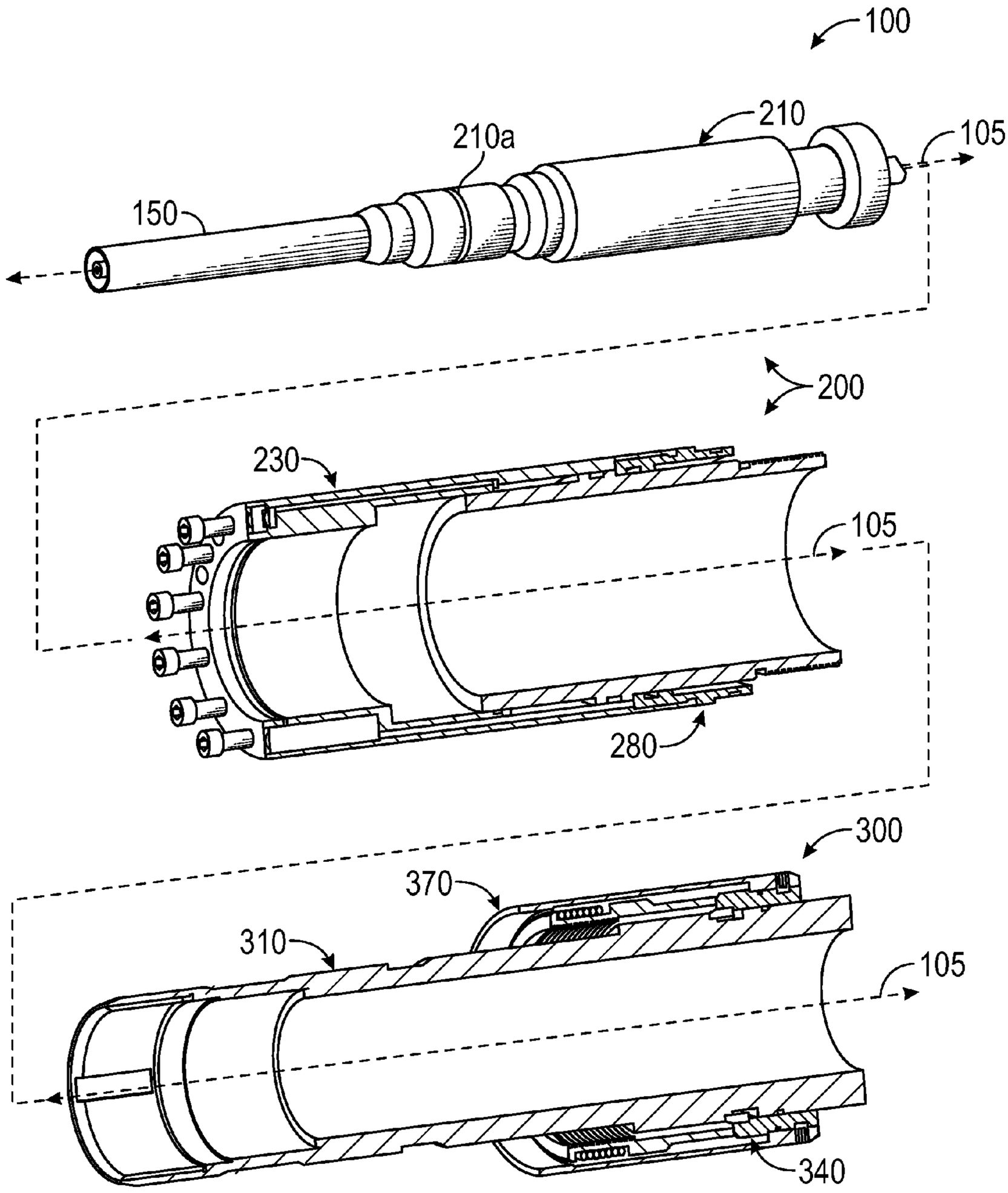
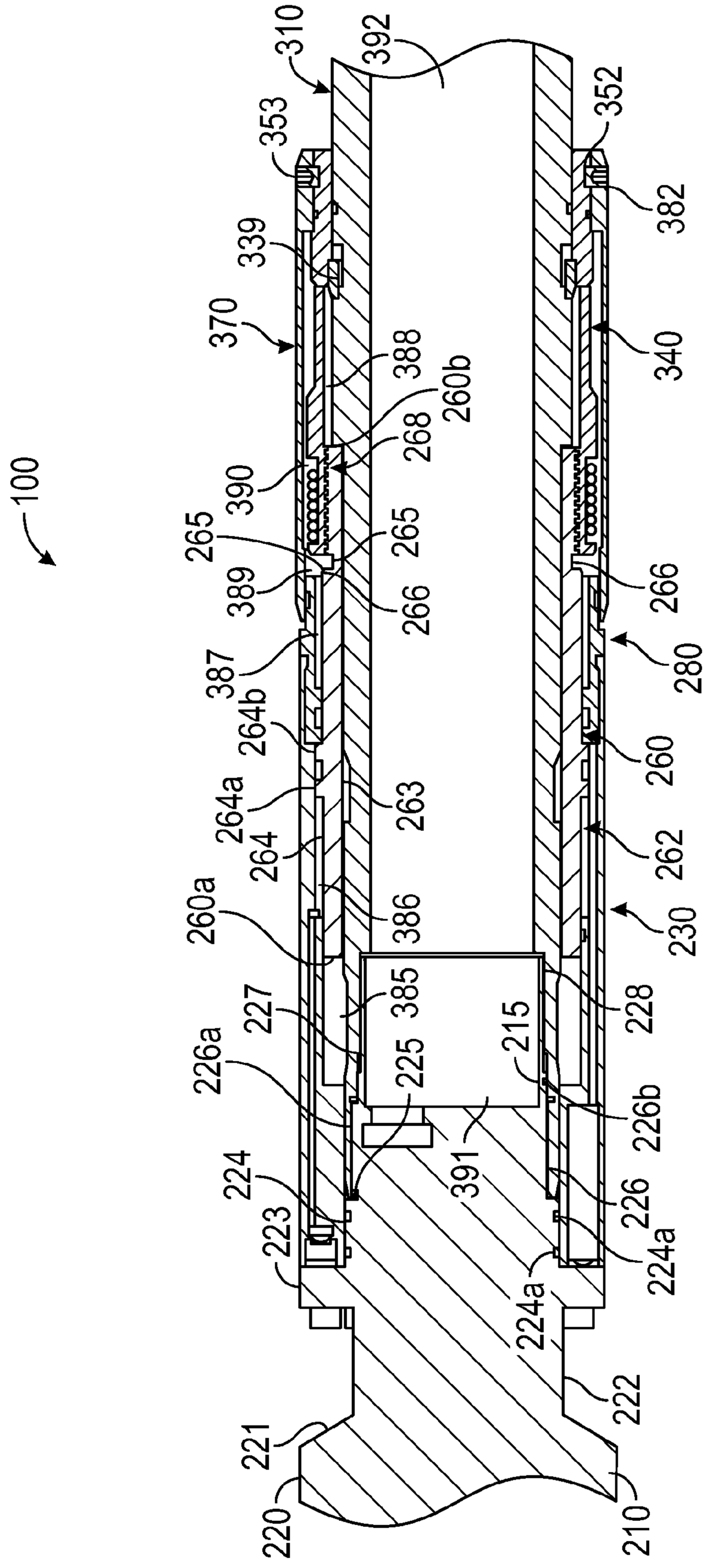


FIG. 1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264a
263
264
262
260a
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230
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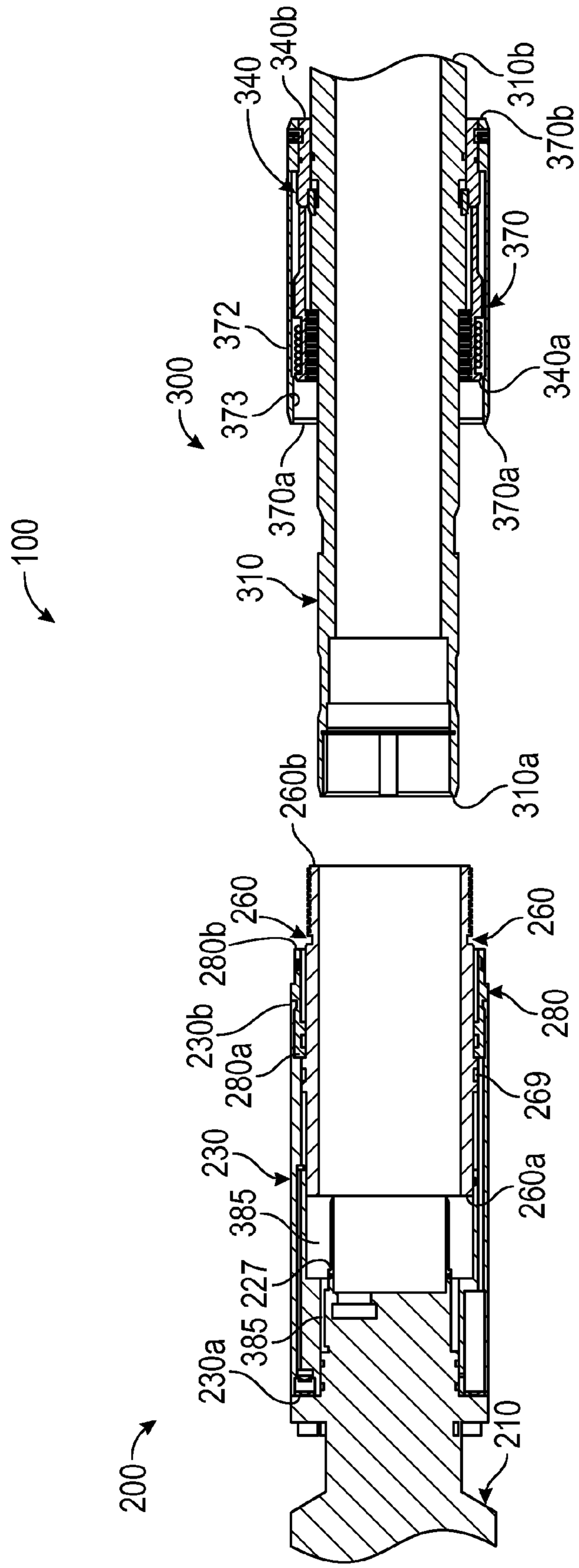
FIG. 2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230a
210

FIG. 3

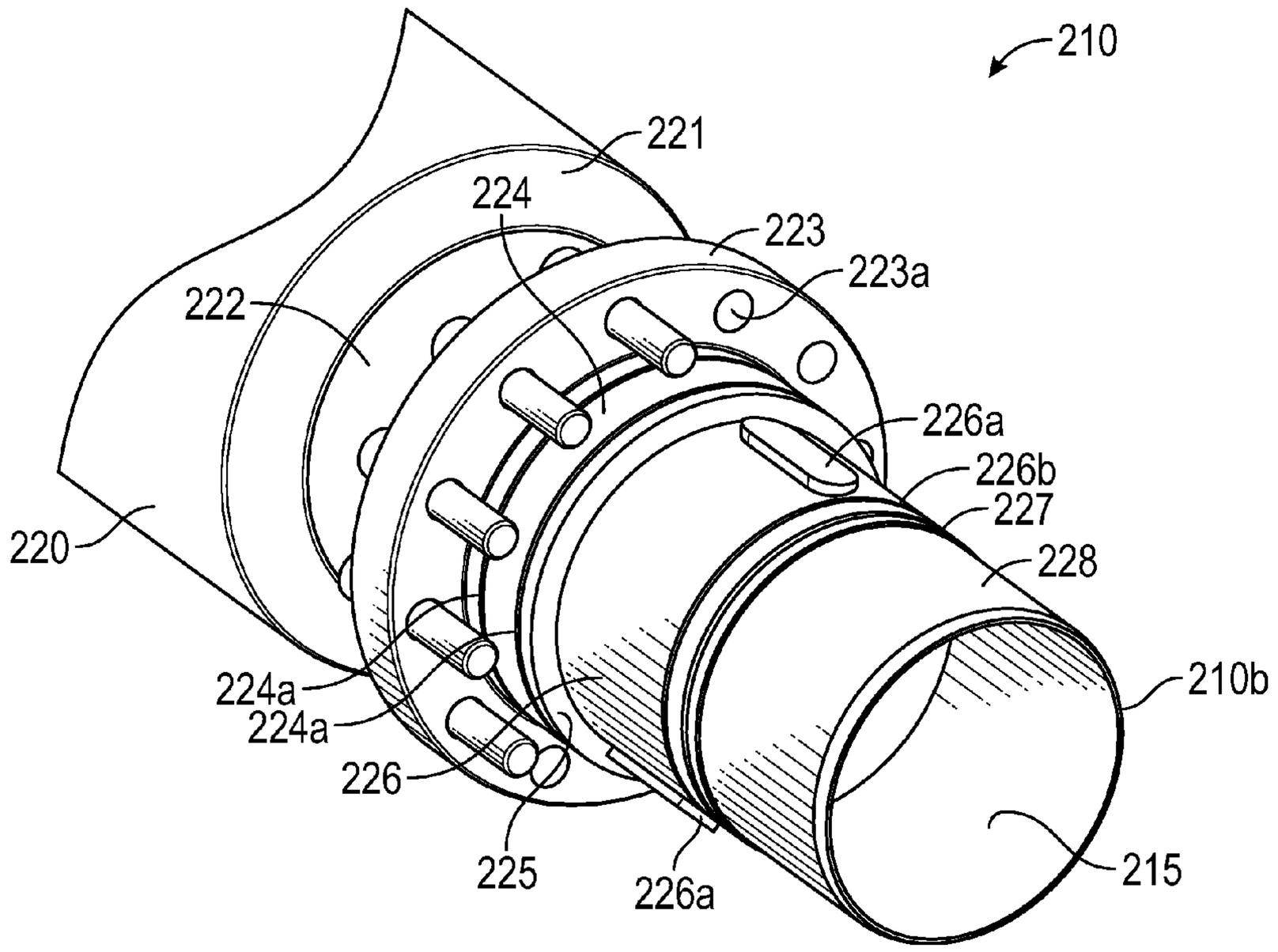
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FIG. 4

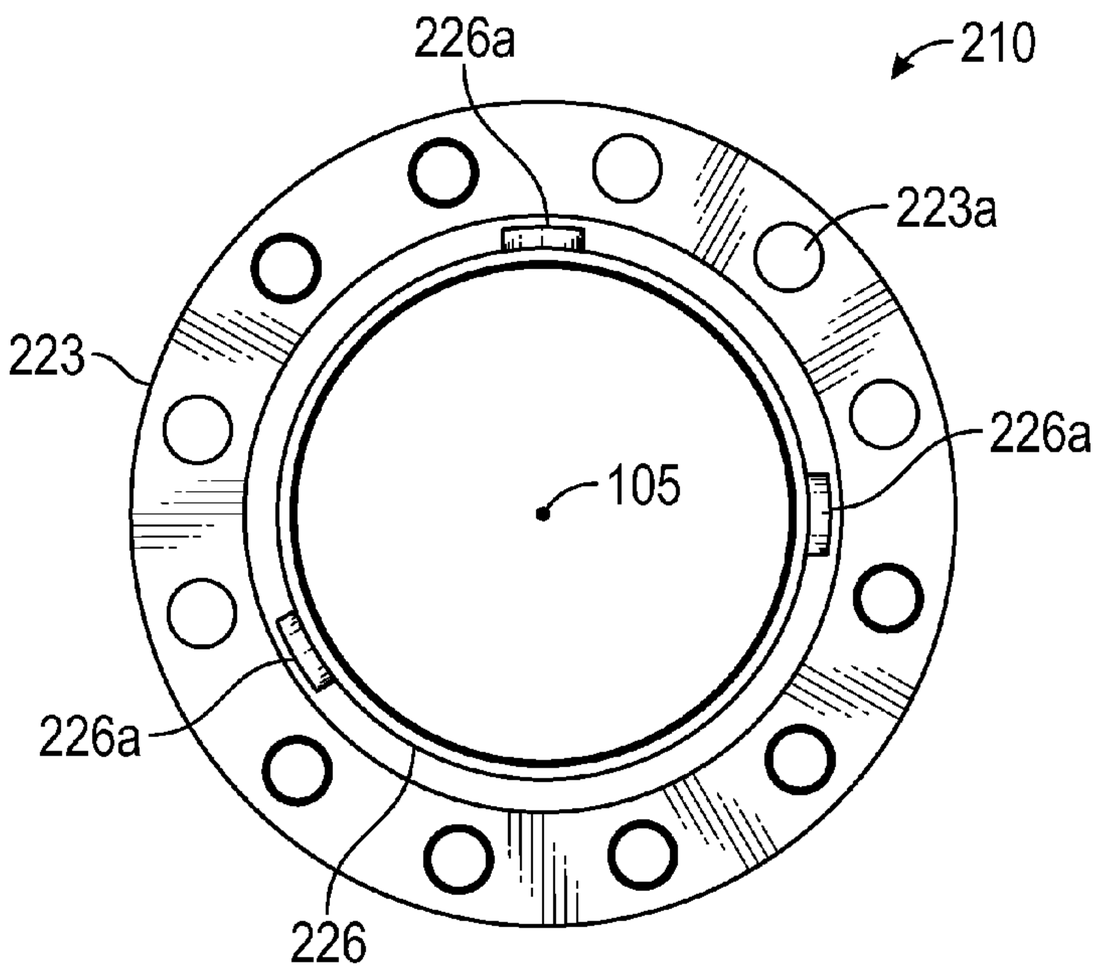
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FIG. 5

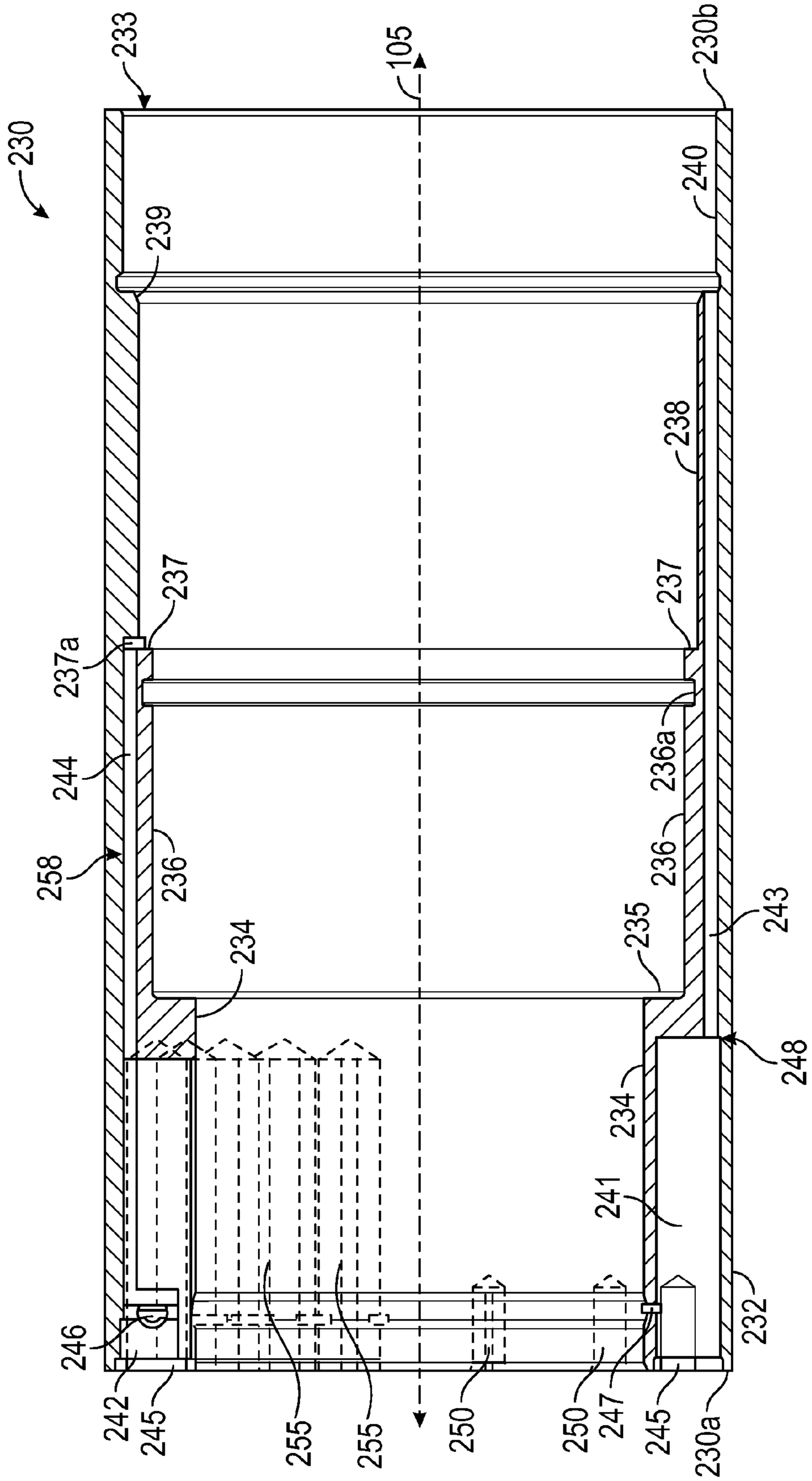
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FIG. 6

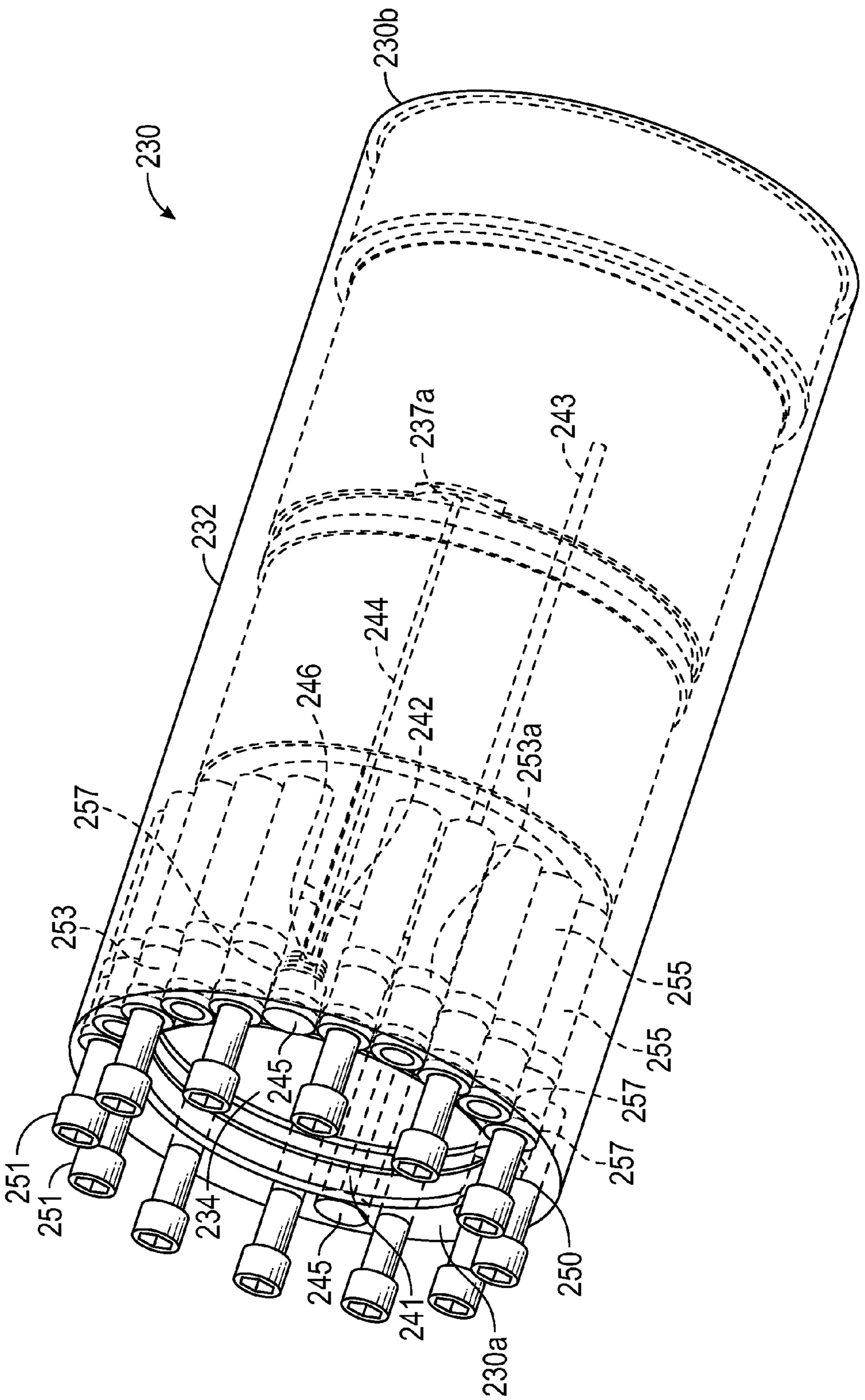
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FIG. 7

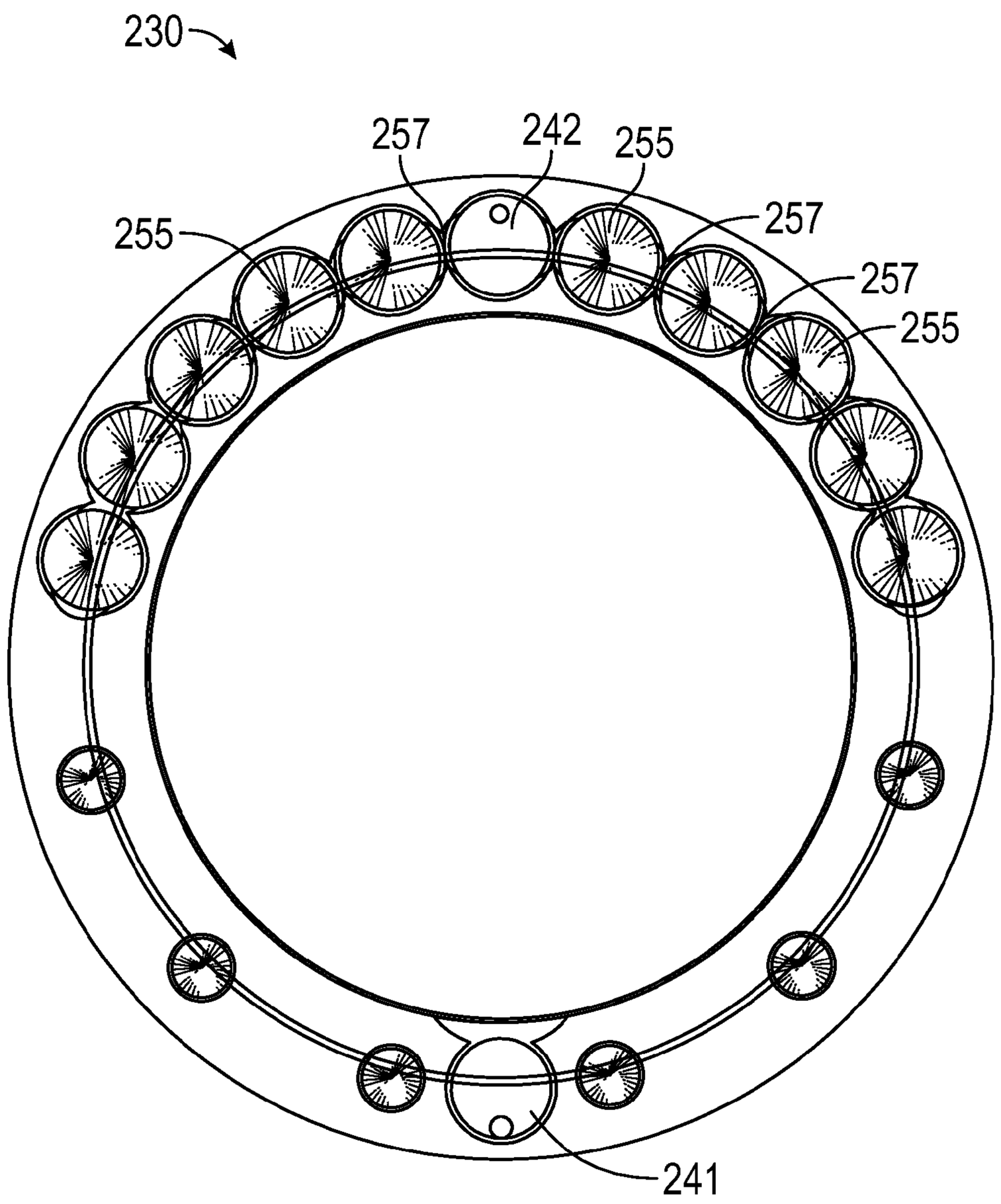

FIG. 8

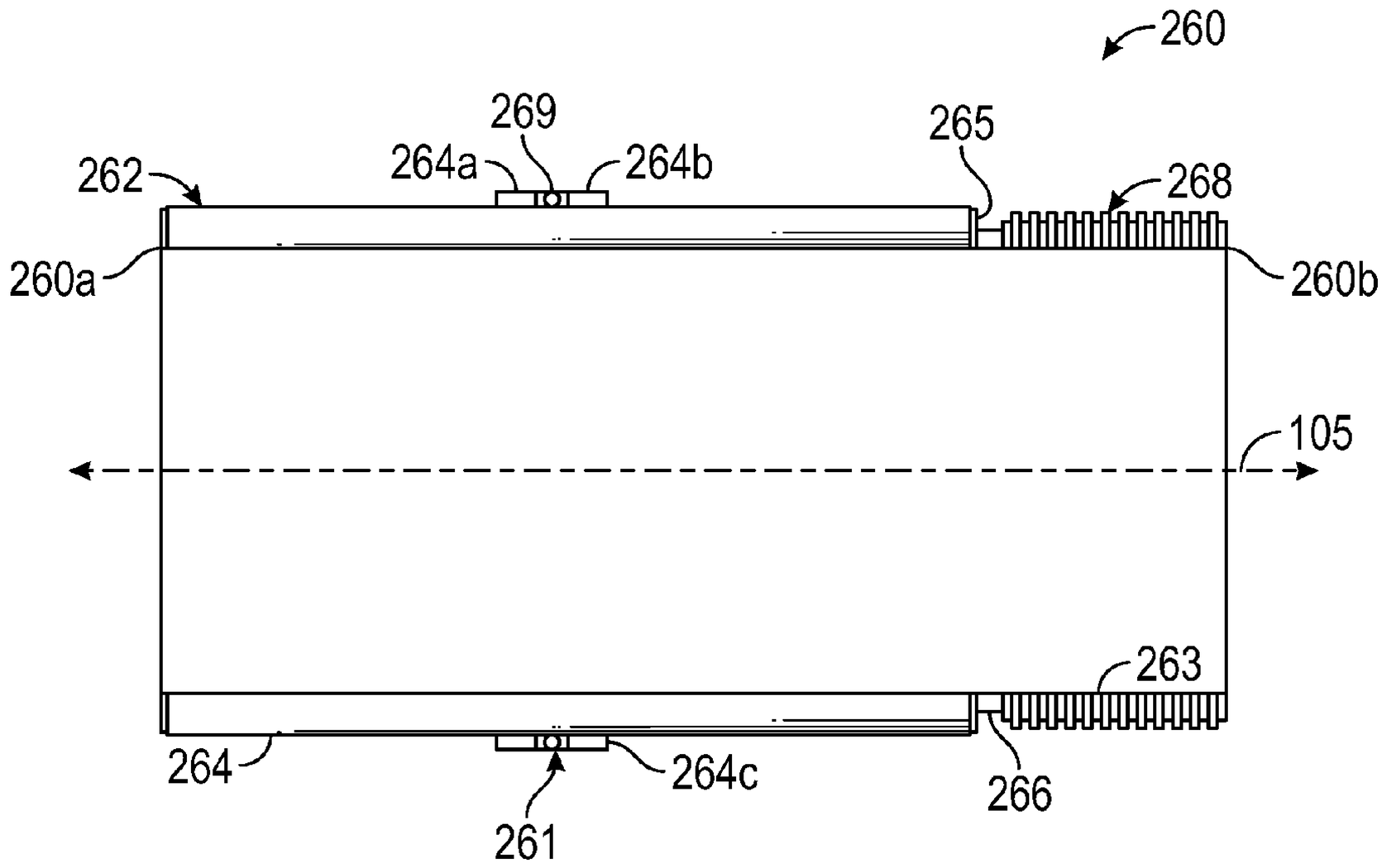
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FIG. 9

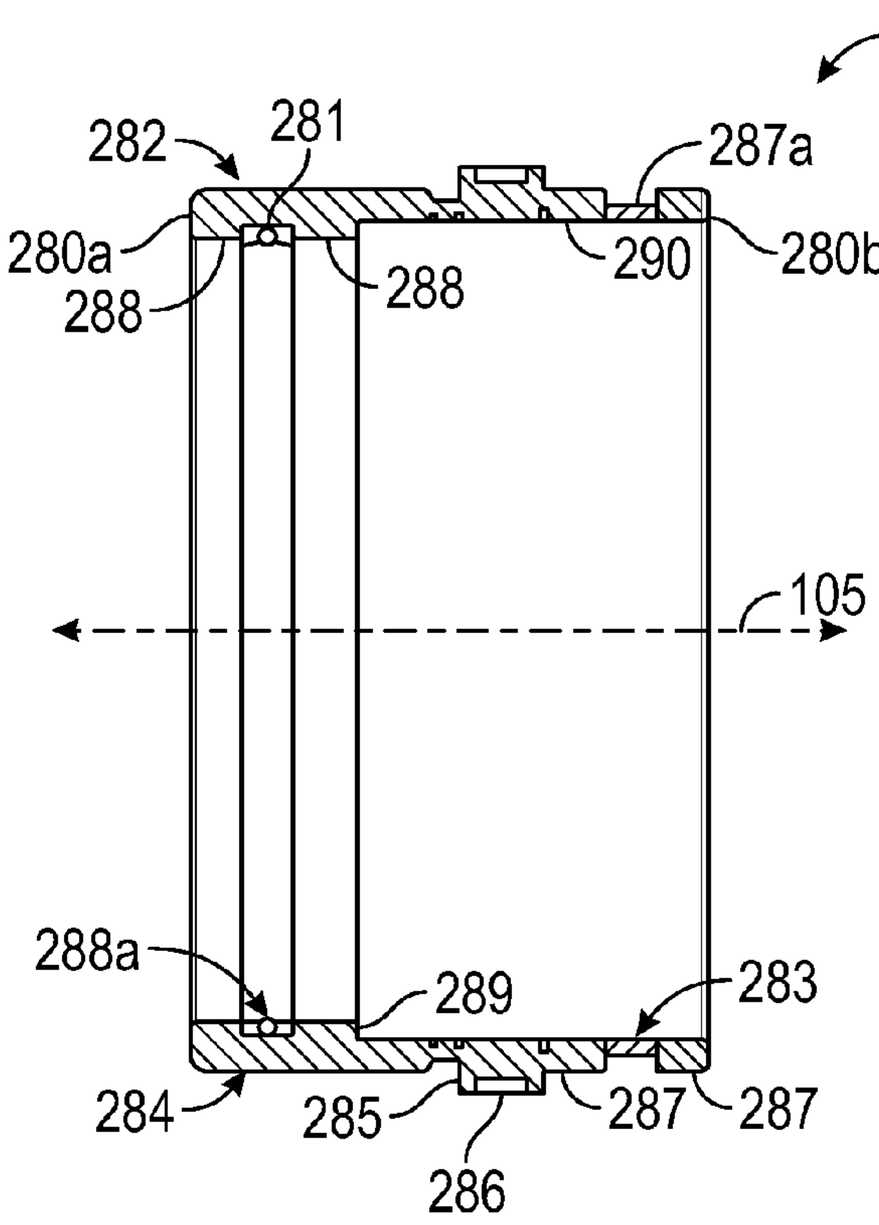
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FIG. 10

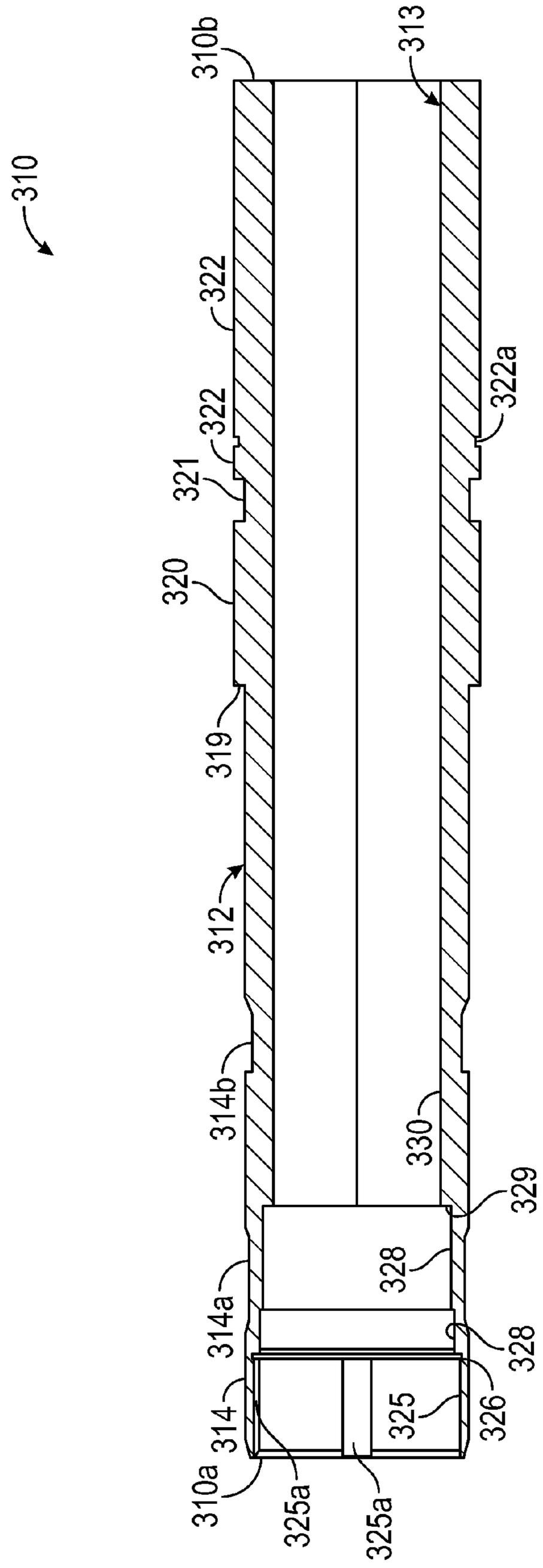
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FIG. 11

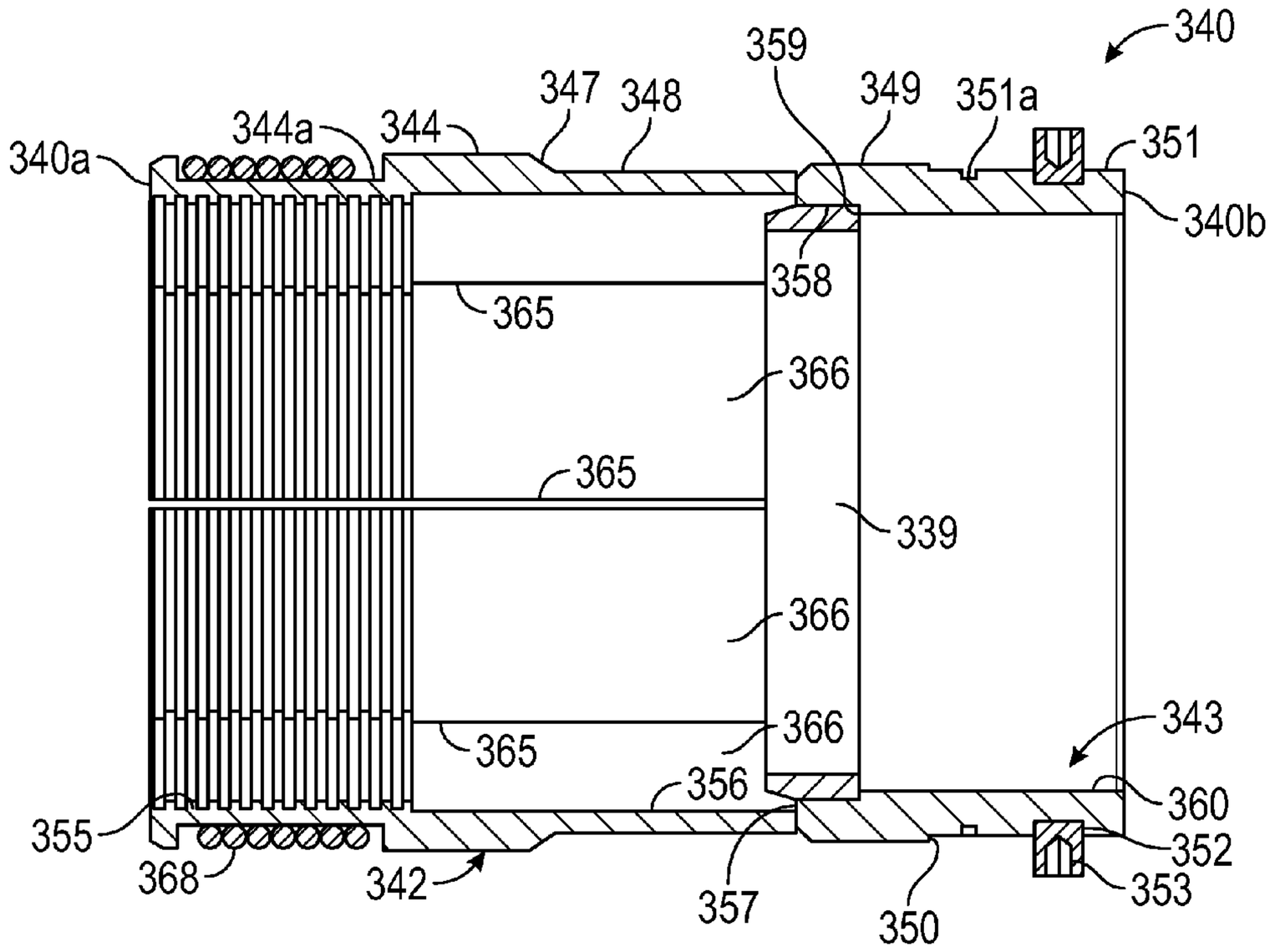
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FIG. 12

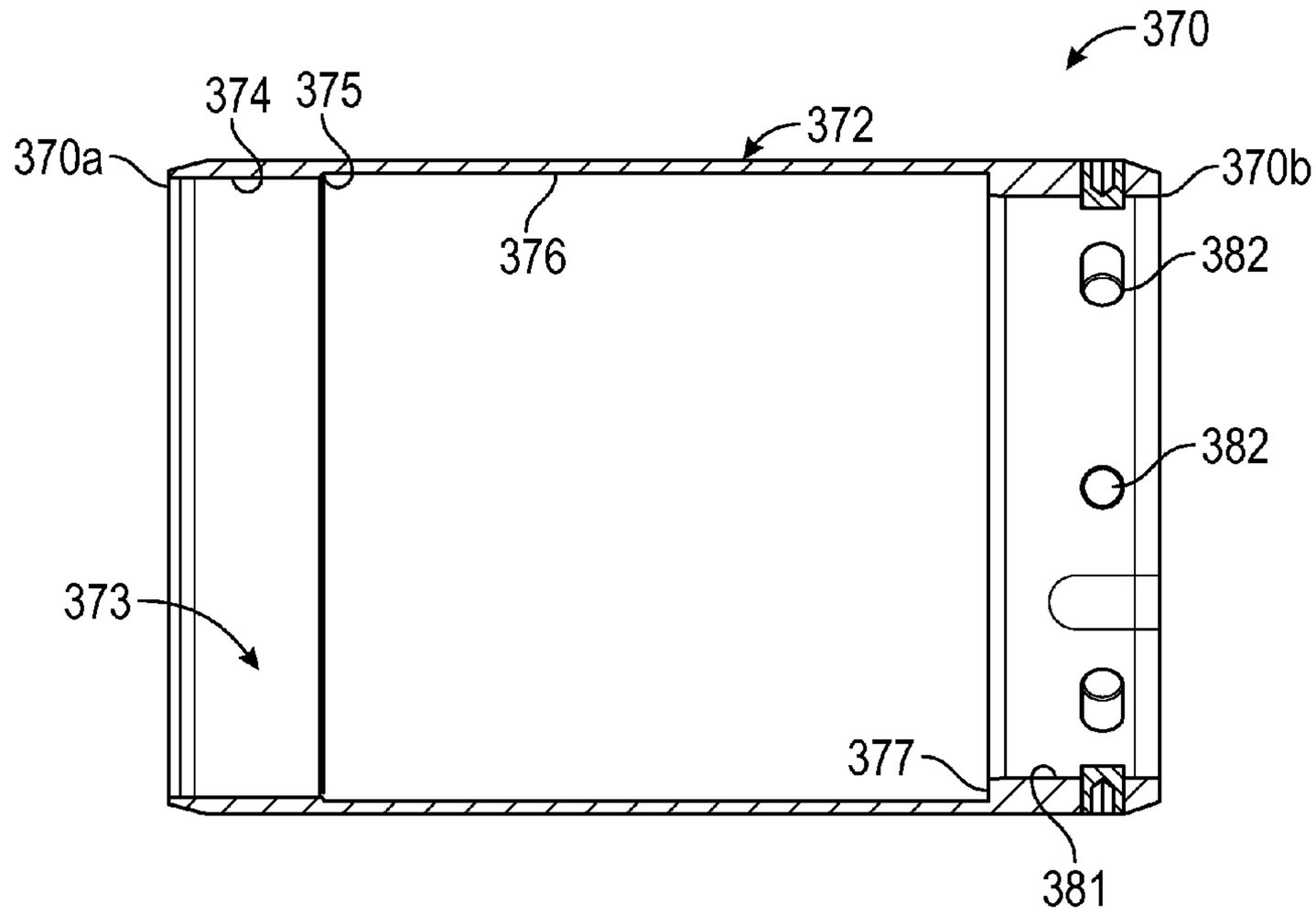
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FIG. 13

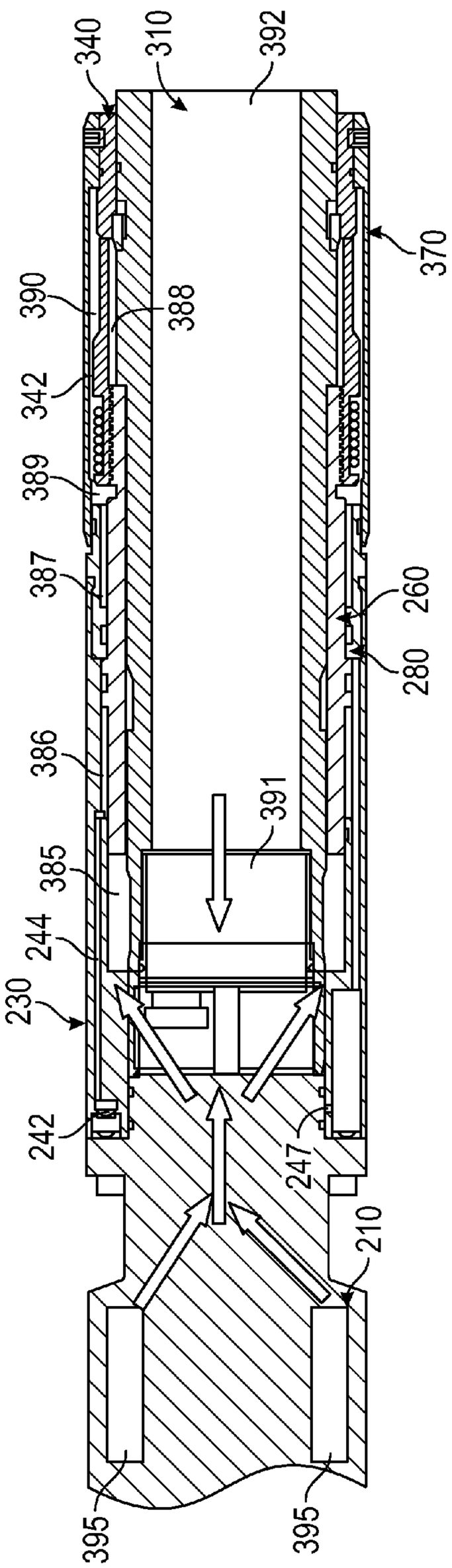
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FIG. 14

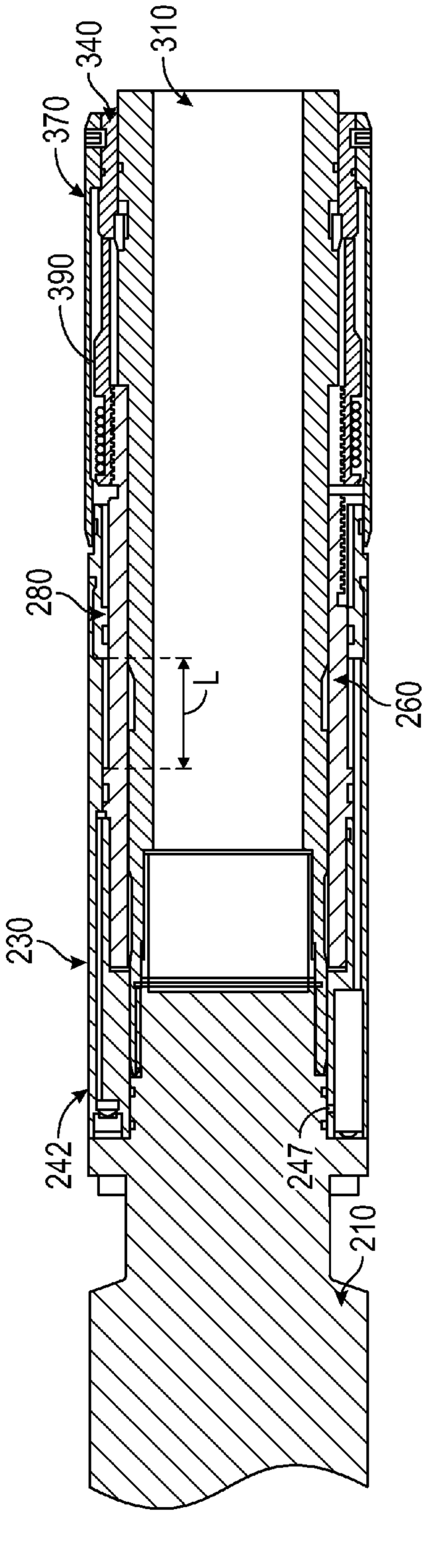
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FIG. 15

TOOL CONNECTION RELEASE SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

Not applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable.

BACKGROUND

This disclosure relates to a tool connection release system for one or more pieces of equipment that may be positioned in a borehole, a well, subsea, or other environment that allows the disconnection of various connections (e.g., electrical, hydraulic, optical, and/or multi-connector) in a high pressure environment. More particularly, this disclosure relates to systems for hydraulically disconnecting a tool independent of the environmental pressure. The systems may also include a secondary release mechanism.

Traditionally, if a tool package suspended from an armored or coiled tubing umbilical is to be recovered, the tool is released to allow heavy lift capable equipment using a retrieval string to be deployed to recover the tool. For hydraulic release of the tool, a piston would have to overcome the external pressure in the well, which can be as high as 24,000 psi or more. This high pressure then may lead the line pressure to be higher than the external pressure to allow actuation of the piston. Shear pins have also been conventionally used as a disconnection means, but shear pins are delicate and typically highly loaded, and can suffer fracture due to fatigue or localized corrosion from stress corrosion cracking.

BRIEF SUMMARY OF THE DISCLOSURE

In an embodiment, a tool connection release system includes a housing having a first portion and a second portion, a piston disposed at least partially within the housing first portion and at least partially within the housing second portion, a first fluid chamber including a first pressurized fluid acting against the piston, a fluid source coupled to the first fluid chamber, and a second fluid chamber including a second pressurized fluid acting against the piston to oppose the first pressurized fluid and pressure-balance the piston. Moreover, addition of a fluid from the fluid source to the pressure-balanced piston causes the piston to move and the first housing portion to separate from the second housing portion.

In an embodiment, a tool connection release system includes a housing having a first portion and a second portion, the first portion being coupled to a cable, a piston having a first end axially disposed at least partially within the housing first portion, and a plurality of threads at a second end. In addition, the release system includes a release nut disposed within the housing second portion and having a plurality of threads at an interior portion of a first end, a recess at an exterior portion of the first end, a second end, and a plurality of circumferentially disposed slots that pass through the plurality of threads and the recess in the first end, the second end being attached to a portion of the housing second end. Further, the threaded exterior portion of the piston is configured to releasably engage the threaded interior portion of the release nut and the plurality of circumferentially disposed slots is configured to allow the release nut first end to move radially outward and disengage the threaded exterior portion of the piston from the threaded interior portion of the release nut such that the piston and the housing first portion can be separated from the release nut and the housing second portion.

In an embodiment, a tool connection release system includes a plug connector having a first end and a second end, the first end coupled to a cable, and an outer portion of the second end having at least one axial protrusion. The release system further includes an actuation cylinder housing having a first end coupled to the plug connector, a second end, and a plurality of circumferentially spaced galleries, and a piston having a first end, a second end, and a plurality of threads at an exterior portion of the second end, the piston being axially disposed at least partially within the activation cylinder housing and forming a first cavity therein. In addition, the release system includes a piston cap that is disposed around the piston and forms a second cavity therein, threadably engages the second end of the actuation cylinder, and is configured to retain the first end of the piston within the actuation cylinder, and a motor head having a first end and a second end, an inner portion of the first end having at least one axial recess configured to engage the protrusion on the outer portion of the plug connector second end. Moreover, the release system includes a release nut having a plurality of threads at an interior portion of a first end, a recess at an exterior portion of the first end, a second end, and a biasing member disposed in the recess, and a protection sleeve disposed about the release nut and a portion of the piston cap, the sleeve forming a third cavity with the release nut. Furthermore, the piston is configured to axially slide around an outer portion of the motor head and the plurality of threads on the exterior portion of the piston second end is configured to releasably engage the threads on the interior portion of the release nut first end upon addition of a pressurized fluid.

Embodiments described herein comprise a combination of features and advantages intended to address various shortcomings associated with certain prior devices, systems, and methods. The foregoing has outlined rather broadly the features and technical advantages of the disclosure such that the detailed description of the disclosure that follows may be better understood. The various characteristics described above, as well as other features, will be readily apparent to those skilled in the art upon reading the following detailed description, and by referring to the accompanying drawings. It should be appreciated by those skilled in the art that the conception and the specific embodiments disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the disclosure. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the disclosure as set forth in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

For a detailed description of the various embodiments, reference will now be made to the accompanying drawings in which:

FIG. **1** is a schematic exploded and partial cross-sectional view of a tool release system with a plug connector and motor head in accordance with the principles described herein;

FIG. **2** is a cross-sectional side view of the release system of FIG. **1**;

FIG. **3** is a cross-sectional side view of the release system of FIG. **2** in a disconnected state;

FIG. **4** is an isometric view of the plug connector of the release system of FIG. **2**;

FIG. **5** is a front view of the plug connector of FIG. **4**;

FIG. **6** is a cross-sectional side view of the actuation cylinder housing of the release system of FIG. **2**;

FIG. **7** is an isometric view of the actuation cylinder housing of FIG. **6**;

FIG. **8** is a cross-sectional front view of the actuation cylinder housing of FIG. **6**;

FIG. **9** is a cross-sectional side view of the piston of the release system of FIG. **2**;

FIG. **10** is a cross-sectional side view of the piston cap of the release system of FIG. **2**;

FIG. **11** is a cross-sectional side view of the motor head of the release system of FIG. **2**;

FIG. **12** is a cross-sectional side view of the release nut of the release system of FIG. **2**;

FIG. **13** is a cross-sectional side view of the protection sleeve of the release system of FIG. **2**;

FIG. **14** is a cross-sectional side view of the release system of FIG. **2** in a connected state; and

FIG. **15** is a cross-sectional side view of the release system of FIG. **2** in a disconnected state.

DETAILED DESCRIPTION

The following discussion is directed to various exemplary embodiments. However, one skilled in the art will understand that the examples disclosed herein have broad application, and that the discussion of any embodiment is meant only to be exemplary of that embodiment, and not intended to suggest that the scope of the disclosures, including the claims, is limited to that embodiment.

Certain terms are used throughout the following description and claim to refer to particular system components. This document does not intend to distinguish between components that differ in name but not function. Moreover, the drawing figures are not necessarily to scale. Certain features of the disclosure may be shown exaggerated in scale or in somewhat schematic form, and some details of conventional elements may not be shown in the interest of clarity and conciseness.

In the following discussion and in the claims, the terms "including" and "comprising" are used in an open-ended fashion, and thus should be interpreted to mean "including, but not limited to . . . " Also, the term "couple" or "couples" is intended to mean either an indirect or direct connection. Thus, if a first device couples to a second device, that connection may be through a direct connection, or through an indirect connection via other devices, components, and connections. In addition, as used herein, the terms "axial" and "axially" generally mean along or parallel to a central axis (e.g., central axis of a body or a port), while the terms "radial" and "radially" generally mean perpendicular to the central axis. For instance, an axial distance refers to a distance measured along or parallel to the central axis, and a radial distance means a distance measured perpendicular to the central axis. Still further, reference to "up" or "down" may be made for purposes of description with "up," "upper," "upward," or "above" meaning generally toward or closer to the surface of the earth, and with "down," "lower," "downward," or "below" meaning generally away or further from the surface of the earth.

The present disclosure relates to a hydraulic tool connection release system that functions independent of environmental pressure and provides a consistent release pressure. The system may also include a secondary release means.

Referring now to FIG. **1**, the tool connection release system or release system **100** allows the disconnection of various connections (e.g., electrical, hydraulic, optical, and/or multi-connector) to a service tool in a high pressure environment. The release system **100** comprises a central axis **105** and a first or upper end **200** that releasably connects to a second or lower end **300**. The upper end **200** includes a plug connector **210** configured to connect to a cable **150**, shown in the top portion of FIG. **1**. The remaining components of the upper end **200**, described in further detail below, are shown in the middle portion of FIG. **1**; and the components of the lower end **300** are shown in the bottom portion of FIG. **1**.

Referring now to FIGS. **1** and **2**, the plug connector **210** of the first or upper end **200** of the release system **100** is coupled to an actuation cylinder housing **230**, a piston **260** disposed in a portion of the cylinder housing **230**, and a piston cap **280** configured to engage the cylinder housing **230** and retain at least a portion of the piston **260** within the cylinder housing **230**. The plug connector **210** of the upper end **200** is configured to connect to a cable **150** that extends upward to the surface. The cable may be connected to the plug connector **210** by any manner known in the art. See, for example, U.S. Patent Application Publication No. 2013/0312996, which is incorporated in its entirety by reference herein. The cable may be any type of cable standard in the art including, but not limited to, an armored or coiled tubing umbilical, which may contain high voltage (HV) power feed cables for pumps or heaters as well as instrumentation and at least one hydraulic line for actuation of the release system.

Referring now to FIGS. **1**, **2**, **4**, and **5**, the plug connector **210** comprises a first annular end **210***a* opposite a second annular end **210***b* and a generally cylindrical inner surface **215**. For clarity, the various electrical, hydraulic, and optical connections are removed, but would generally be located within the cylindrical inner surface **215**.

Referring now to FIGS. **4** and **5**, the plug connector **210** further comprises a first cylindrical outer surface **220** extending axially from the first end **210***a* (FIG. **1**) to an outer angular shoulder **221** that extends axially toward plug connector second end **210***b* and radially inward to a second cylindrical outer surface **222**. Second cylindrical outer surface **222** extends axially to a flange **223** having a plurality of circumferentially spaced through holes **223***a*. A third cylindrical outer surface **224** extends axially from the flange **223** to a first downward-facing shoulder **225**. The third cylindrical outer surface **224** includes two grooves **224***a*, each configured to receive a seal. The seal may be any type of seal known in the art including, but not limited to an O-ring, metal C-seals, and labyrinth seals with back-up rings. A fourth cylindrical outer surface **226** extends axially between the first downward-facing shoulder **225** and a second downward-facing shoulder **227**. The fourth cylindrical outer surface **226** has a plurality of protruding keys **226***a* that extend axially between the first downward-facing shoulder **225** and a groove **226***b* disposed on the fourth cylindrical outer surface **226** proximate a fifth cylindrical outer surface **228**. In the present embodiment, the fourth cylindrical surface **226** has three keys **226***a*; in other embodiments, surface **226** may have as few as one key or four or more keys.

Referring now to FIGS. **2**, **3**, **6**, and **7**, the actuation cylinder housing **230** is tubular and has a first end **230***a* opposite a second end **230***b*, a cylindrical outer surface **232**, and a generally cylindrical inner surface **233**. The inner surface **233** comprises a first cylindrical surface **234** that

extends axially from the housing first end **230***a* to a first downward-facing shoulder **235**. A second inner cylindrical surface **236** extends axially from the first shoulder **235** to a second downward-facing shoulder **237**. The diameter of the first cylindrical surface **234** is smaller than the diameter of the second cylindrical surface **236**. The second cylindrical surface **236** includes a groove **236***a* disposed proximate the second downward-facing shoulder **237**. A third cylindrical surface **238** extends axially from the second shoulder **237** to a graduated downward-facing shoulder **239**, and a threaded cylindrical surface **240** extends from the shoulder **239** to the second end **230***b*.

Referring to FIGS. **6** and **7**, the housing **230** further comprises a first cylindrical chamber **241** that extends between the housing first end **230***a* and a first elongate channel **243**. The first cylindrical chamber **241** has a cover **245** covering the opening of the chamber at housing first end **230***a*, and an inlet port **247** radially disposed proximate the housing first end **230***a* and in fluid communication with a control line or hydraulic fluid source (not shown). The first cylindrical chamber **241** and the first elongate channel **243** together form a first fluid chamber **248**. The cover **245** may be secured to the housing first end **230***a* in any manner known in the art including, but not limited to, welded, threaded, or any other suitable mechanical fastener that is configured to seal with housing **230**. The first elongate channel **243** extends axially from the first chamber **241** through to the graduated downward-facing shoulder **239**. The first chamber **241** and the first elongate channel **243** are in fluid communication, and the first elongate channel **243** is in fluid communication with the housing inner surface **233** at shoulder **239**.

The housing **230** also comprises a second cylindrical chamber **242** that extends between the housing first end **230***a* and a second elongate channel **244**. The second cylindrical chamber **242**, like the first cylindrical chamber **241**, has a cover **245** covering the opening of the chamber at housing first end **230***a*. The second cylindrical chamber **242** also contains a sealed opening **246** having an outer diameter substantially similar to the inner diameter of the second cylindrical chamber **242** to form a seal. The second elongate channel **244** extends axially from the second chamber **242** to an opening **237***a* disposed at the second shoulder **237**. The second chamber **242** and the second elongate channel **244** are in fluid communication after the sealed opening **246** is opened. The sealed opening **246** may be any type of sealed opening or barrier capable of opening under a predetermined pressure known in the art including, but not limited to, a burst disc. The sealed opening **246** may also be referred to as a burst disc **246** that opens or ruptures at a predetermined pressure. Until the burst disc **246** bursts, the second cylindrical chamber **242** is at 1 atm and the second elongate channel **244** is in fluid communication with the housing third cylindrical surface **238** via the opening **237***a* at shoulder **237**. The second elongate channel **244** and the opening **237***a* form a second fluid chamber **258**.

Referring now to FIGS. **7** and **8**, the housing first end **230***a* further includes a plurality of threaded bores **250** spaced circumferentially about the central axis **105** between the outer surface **232** and the first cylindrical surface **234**. The threaded bores **250** are configured to accept threaded fasteners or bolts **251**. However, a portion of the bolts **251** threadably engage a plug **253**, each plug being coupled to and disposed in a cylindrical overflow cavity **255** disposed circumferentially between the outer surface **232** and the first cylindrical surface **234** and extending from the first end **230***a* toward first downward-facing shoulder **235**. Each plug **253** may be coupled to each cavity **255** in any manner known in the art including, but not limited to, welded, threaded, or any other suitable mechanical fastener configured to seal with housing **230**. In the present embodiment, there are ten cavities **255** disposed about the second cylindrical chamber **242** (five on either side) with no cavities **255** disposed about the first cylindrical chamber **241** for the remaining bolts or fasteners, as shown in FIGS. **6** and **7**. Though, in the embodiment as shown, plugs **253** are disposed in each cavity **255**, a bolt **251** need not be threadably engaged in each plug **253**.

Referring still to FIGS. **7** and **8**, furthermore, each cavity **255** is in fluid communication with one another and with the second chamber **242** through connecting galleries **257** disposed between and connecting each adjacent cavity **255** and chamber **242** proximate upper end **230***a* of the housing **230**. Each plug **253** includes axial channels **253***a* that allow fluid communication between the portion of the cavity **255** surrounding the plug **253** and the portion of the cavity below the plug **253**. Thus, each cavity **255** is in fluid communication with the other cavities **255**, the second chamber **242**, second elongate channel **244** once the burst disc **246** is breached, and the opening **237***a* at shoulder **237**

Referring now to FIG. **9**, the piston **260** is tubular and has a first or upper end **260***a* opposite a second or lower end **260***b*, a generally cylindrical outer surface **262**, and a cylindrical inner surface **263**. The outer surface **262** comprises a first cylindrical surface **264** that extends axially from the housing first end **260***a* to a downward-facing shoulder **265**. A second cylindrical surface **266** extends axially from the shoulder **265** to a threaded portion **268**, and the threaded portion **268** extends from the second cylindrical surface **266** to the piston second side **260***b*. The first cylindrical surface **264** includes a first and a second annular protrusion or ring **264***a*, **264***b*, respectively, spaced apart to form an annular groove **261** therebetween and disposed approximately midway between the piston first end **260***a* and the shoulder **265**. A sealing element **269** may be disposed in the annular groove **261**, and may be any type of seal known in the art including, but not limited to, an O-seal, T-seal with back up rings, polymeric spring energized lip seals, metallic lip seals, and C-rings. The diameter of the first cylindrical surface **264** is greater than the diameter of the second cylindrical surface **266**.

Referring now to FIGS. **3** and **10**, the piston cap **280** is tubular and has a first or upper end **280***a* opposite a second or lower end **280***b*, a generally cylindrical outer surface **282**, and a generally cylindrical inner surface **283**. The outer surface **282** comprises a threaded portion **284** that extends axially from the piston cap first end **280***a* to an upward-facing shoulder **285**. An annular protrusion or ring **286** extends axially from the upward-facing shoulder **285** to a cylindrical surface **287**, and the cylindrical surface **287** extends from the protrusion **286** to the piston cap second end **260***b*. The cylindrical surface **287** includes an annular indention or groove **287***a* spaced approximately midway between the protrusion **286** and the piston cap second end **280***b*. The indention **287***a* is configured to receive a seal. The seal may be any type of seal known in the art including, but not limited to an O-ring, O-seal, T-seal with back up rings, polymeric spring energized lip seals, metallic lip seals, and C-rings.

The piston cap **280** further comprises a first cylindrical surface **288** that extends between the piston cap first end **280***a* and a downward-facing shoulder **289**. The first cylindrical surface **288** has an annular groove or indentation **288***a* disposed approximately midway between the piston cap first

end **280***a* and the shoulder **289**. The indention **288***a* is configured to house a seal. The seal may be any type of seal known in the art including, but not limited to an O-ring, O-seal, T-seal with back up rings, polymeric spring energized lip seals, metallic lip seals, and C-rings.

Referring now to FIGS. **2** and **3**, the second or lower end **300** of the release system **100** comprises a motor head **310**, a release nut **340** disposed about a portion of the motor head **310**, and a protection sleeve **370** disposed about and coupled to the release nut **340**. The motor head **310** of the lower end **300** is configured to connect to a service tool (not shown). The service tool may be any type of service tool standard in the art including, but not limited to, an electric submersible pump.

Referring now to FIGS. **2**, **3**, and **11**, the motor head **310** comprises a first annular end **310***a* opposite a second annular end **310***b*, a generally cylindrical outer surface **312**, and a generally cylindrical inner surface **313**. For clarity, the various electrical, hydraulic, and optical connections are removed, but would generally be located within the cylindrical inner surface **313**.

The generally cylindrical outer surface **312** of motor head **310** comprises a first cylindrical outer surface **314** extending axially from the first end **310***a* to an outer upward-facing shoulder **319**. The first cylindrical outer surface **314** includes a first elongate annular indentation **314***a* disposed proximate motor head first end **310***a* and a second elongate annular indentation **314***b* disposed approximately midway between motor head first end **310***a* and shoulder **319**. A second cylindrical outer surface **320** extends axially from the shoulder **319** to a third indentation **321**; the third indentation is configured to receive a retention member **339**. The retention member **339** may be any type of retention member known in the art including, but not limited to, a snap ring. A third cylindrical outer surface **322** extends axially from the third indentation **321** to the motor head second end **310***b*. The third cylindrical outer surface **322** includes a groove **322***a* configured to receive a seal. The seal may be any type of seal known in the art including, but not limited to an O-ring, O-seal, T-seal with back up rings, polymeric spring energized lip seals, metallic lip seals, and C-rings.

The generally cylindrical inner surface **313** of motor head **310** comprises a first cylindrical inner surface **325** extending axially from the first end **310***a* to a first upward-facing shoulder **326**. A second cylindrical inner surface **328** having a reduced diameter extends from the first shoulder **326** to a second upward-facing shoulder **329**. A third cylindrical inner surface **330** having a reduced diameter extends from the second shoulder **329** to the motor head second end **310***b*. In the present embodiment, the first cylindrical inner surface **325** has three axial cutouts or slots **325***a*; in other embodiments, surface **325** may have as few as one cutout or slot, or four or more cutouts or slots.

Referring now to FIGS. **2**, **3**, and **12**, the release nut **340** is tubular and has a first or upper end **340***a* opposite a second or lower end **340***b*, a generally cylindrical outer surface **342**, and a generally cylindrical inner surface **343**. The generally cylindrical outer surface **342** of the release nut **340** comprises a first cylindrical outer surface **344** extending axially from the first end **340***a* to an outer angular shoulder **347** that extends axially toward release nut second end **340***b* and radially inward to a second cylindrical outer surface **348**. The first cylindrical outer surface **344** includes an elongate annular indentation or recess **344***a* disposed proximate release nut first end **340***a*. The recess **344***a* is configured to receive and retain a biasing member **368**. The biasing member may be any biasing member known in the art including, but not limited to, a close coiled spring, a plurality of wrap springs, or a plurality of single circlips. The second cylindrical outer surface **348** extends axially to a third cylindrical outer surface **349** having a slightly larger diameter. A fourth cylindrical outer surface **351** extends axially from a downward-facing shoulder **350** to the release nut second end **340***b*. The fourth cylindrical outer surface **351** includes a groove **351***a* disposed proximate shoulder **350** configured to receive a seal. The seal may be any type of seal known in the art including, but not limited to an O-ring, O-seal, T-seal with back up rings, polymeric spring energized lip seals, metallic lip seals, and C-rings. The fourth cylindrical outer surface **351** further includes a plurality of threaded radial bores **352** spaced circumferentially about the central axis **105** proximate the release nut second end **340***b*.

The generally cylindrical inner surface **343** of release nut **340** comprises a threaded portion **355** that extends axially from the release nut first end **340***a* to a first inner cylindrical surface **356**. The first inner cylindrical surface **356** extends axially to a first upward-facing shoulder **357**. A second cylindrical surface **358** extends axially from first shoulder **357** to a second upward-facing shoulder **359**. A third inner cylindrical surface **360** extends axially from the second upward-facing shoulder **359** to the release nut second end **340***a*. The second cylindrical surface **358** and second upward-facing shoulder **359** are configured to engage the retention member **339**.

The release nut further comprises a plurality of slots **365** that extend axially from the release nut first end **340***a* to the first shoulder **357**, and extend radially from outer surface **342** through to inner surface **343**, forming a plurality of fingers **366**. The slots allow the fingers **366** to slightly flex radially. Thus, the release nut **340** may also be referred to as a slotted release nut **340**. In the present embodiment, there are eight slots **365** and eight fingers **366** (not all slots **365** are shown). In other embodiments, there may be as few as two slots **365** and two fingers **366**, or there may be more than eight slots **365** and eight fingers **366**.

Referring now to FIGS. **2**, **3**, and **13**, the protection sleeve **370** is tubular and comprises a first or upper end **370***a* opposite a second or lower end **370***b*, a cylindrical outer surface **372**, and a generally cylindrical inner surface **373**. The generally cylindrical inner surface **373** of the protection sleeve **370** comprises a first cylindrical inner surface **374** extending axially from the first end **370***a* to a downward-facing shoulder **375**. A second cylindrical inner surface **376** extends axially from the downward-facing shoulder **375** to an upward-facing shoulder **377**; and a third cylindrical inner surface **381** extends from the upward-facing shoulder **377** to protection sleeve second end **370***b*. The third cylindrical inner surface **381** has a plurality of through bores **382** spaced circumferentially about the central axis **105** proximate the sleeve second end **370***b*. In the present embodiment, the third cylindrical inner surface **381** has eight through bores **382**. In other embodiments, the third cylindrical surface **381** may comprise three or more through bores **382**.

The tool connection release system **100** when deployed with a service tool in a high pressure environment and before activation of the release system **100**, as shown in FIG. **2**, includes the plug connector **210** coupled to the actuation cylinder housing **230**. The plurality of threaded bores **250** spaced circumferentially about the central axis **105** of the actuation housing first end **230***a* are configured to align with the plurality of circumferentially spaced through holes **223***a* of the flange **223** portion of the plug connector **210**. The threaded bores **250** are further configured to threadably couple to fasteners or bolts **251** to secure the flange **223** of

the plug connector **210** to the first end **230***a* of the actuation housing **230**. When the plug connector **210** is fastened to the housing **230**, the plug connector third cylindrical outer surface **224** is disposed adjacent a portion of the housing first cylindrical surface **234** proximate the housing first end **230***a*. Seals are disposed in grooves **224***a* to seal between the plug connector third cylindrical outer surface **224** and the housing first cylindrical surface **234**. A seal is disposed in groove **226***b* to seal between the plug connector fourth cylindrical outer surface **226** and the motor head second cylindrical inner surface **328**.

Referring now to FIGS. **2** and **3**, a first annular space or cavity **385**, shown in FIG. **3**, is formed between the first cylindrical surface **234** and second inner cylindrical surface **236** of the housing **230** and the fourth cylindrical outer surface **226** and fifth cylindrical outer surface **228** of the plug connector **210**; the first cavity **385** extends axially from the first downward-facing shoulder **225** to the second end **210***b* of the plug connector **210**.

Referring now to FIG. **2**, the piston cap **280** is configured to threadably engage the housing **230** such that the threaded portion **240** of the housing **230** engages the threaded portion **284** of the piston cap **280**, and housing second end **230***b* is adjacent the upward-facing shoulder **285** of the piston cap. In an alternative embodiment, the piston cap **280** may be welded to housing **230** proximate upward-facing shoulder **285** using any welding method known in the art including, but not limited to, electron beam, laser, or T.I.G.; in this alternative embodiment, other methods of sealing may also be applied. The annular piston cap **280** is radially disposed between a portion of the actuation cylinder housing **230**, a portion of the protection sleeve **370**, and the annular piston **260**. As the piston cap **280** is threadably coupled to the housing **230** and the housing is coupled to the plug connector **210** with bolts **251**, the first and second protrusions **264***a*, **264***b*, respectively, of the piston **260** are retained by the annular piston cap first end **280***a* to prevent the piston **260** from separating from the housing **230** and plug connector **210**.

Referring still to FIG. **2**, the annular piston **260** is radially disposed between the housing **230** and the motor head **310**. More specifically, the piston **260** is disposed in the actuation housing **230** such that the first and second annular protrusions or rings **264***a*, **264***b*, respectively, of the piston **260** slidingly engage the housing third cylindrical surface **238**. A seal **281** is disposed in groove **288***a* of the first cylindrical surface **288** of the piston cap **280**, and sealingly engages the first cylindrical surface **264** of the piston **260**.

A second annular space or cavity **386** is formed radially between the housing third cylindrical surface **238** and the piston first cylindrical surface **264** and axially between the housing second downward-facing shoulder **237** and the first annular protrusion **264***a*. The second cavity **386** is in fluid communication with the second elongate channel **244** in the housing **230**. The axial movement of the piston **260** is restricted in one direction by the housing second downward-facing shoulder **237** along with the housing first downward-facing shoulder **235**, and bound in the opposite direction by the annular piston cap first end **280***a* and the motor head outer upward-facing shoulder **319**.

A seal is disposed between the first and second annular protrusions **264***a*, **264***b*, respectively, to sealingly engage the housing third cylindrical surface **238**. A seal is also disposed in the groove **236***a* of the housing second cylindrical surface **236** about the piston first cylindrical surface **264**.

A third annular space or cavity **387** is formed radially between the piston cap cylindrical surface **287** and the piston first cylindrical surface **264** and axially between the piston cap downward-facing shoulder **289** and the piston cap second end **280***b*.

Referring still to FIG. **2**, the motor head **310** is disposed in the annular piston **260** such that the motor head first cylindrical outer surface **314** slidingly engages the piston cylindrical inner surface **263**, and piston second end **260***b* is disposed adjacent the motor head outer upward-facing shoulder **319**.

The motor head **310** is disposed radially within the actuation cylindrical housing **230**, such that the motor head first end **310***a* is disposed adjacent the plug connector first downward-facing shoulder **225**. In addition, the three axial cutouts or slots **325***a* spaced about the first cylindrical inner surface **325** of the motor head **310** are configured to align with the three keys **226***a* disposed on the fourth cylindrical outer surface **226** of the plug connector **210**. The motor head **310** and the plug connector **210** remain in alignment during connections or disconnections across the axial length of the keys **226***a*, which helps reduce possible damage to the tool connectors housed in the plug connector **210** by controlling the alignment during engagement and separation. In the present embodiment, the location of the keys **226***a* and corresponding slots **325***a* allow connection of the motor head **310** to the plug connector **210** in a single orientation; however, in other embodiments, different keying configurations may be used that employ more or less keys and corresponding slots with locations that may allow connection of the motor head to the plug connector in more than one orientation.

Referring still to FIG. **2**, the motor head **310** is disposed in the annular piston **260** such that the motor head first cylindrical outer surface **314** slidingly engages the piston cylindrical inner surface **263**, and piston second end **260***b* is disposed adjacent the motor head outer upward-facing shoulder **319**.

Referring now to FIGS. **2**, **11**, and **12**, the slotted release nut **340** is radially disposed between the motor head **310**, a portion of the piston **260**, and the protection sleeve **370**. A seal is disposed in groove **322***a* of the third cylindrical outer surface **322** of the motor head **310**, and sealingly engages the third inner cylindrical surface **360** of the slotted release nut **340**. The retention member **339** disposed in motor head indentation **321** extends radially outward past the motor head third cylindrical outer surface **322** to engage the second cylindrical surface **358** and the second upward-facing shoulder **359** of the release nut **340**. Retention member **339** restricts the axial movement of the release nut **340** toward the plug connector **210**.

The slotted release nut **340** is configured to threadably engage the piston **260** such that the threaded portion **355** of the slotted release nut **340** engages the threaded portion **268** of the piston **260**, and release nut first end **340***a* is adjacent the second cylindrical surface **266** of the annular piston **260**. The biasing member **368** disposed in the recess **344***a* of the release nut **340** is configured to maintain the threaded engagement of the piston **260** to the slotted release nut **340** until a sufficient axial force causes the threads **268** of the piston **260** to slide against the threads **355** of the release nut **340** and force the release nut threads to expand or move radially outward. The outward radial movement of the release nut threads **355** is possible due to the plurality slots **365** and resulting fingers **366** of the release nut **340**. In other words, the threads **268** of the piston **260** under a predetermined load will jump the threads **355** of the release nut **340**. The predetermined load is typically about 24,000 lbf and is governed by several factors including, but not limited to the

design of the slots and resulting fingers (e.g., the width and axial length of the slots), the thread profile of the piston and release nut, and the spring reaction load. In an alternative embodiment, several wrap springs with a fewer number of turns to limit the clutch friction force or multiple single circlips could be used for the biasing member **368**.

A fourth annular space or cavity **388** is formed radially between the second cylindrical outer surface **320** of the motor head **310** and the first inner cylindrical surface **356** of the release nut **340**, and axially between the release nut threaded portion **355** and the first upward-facing shoulder **357** of the release nut **340**.

Referring now to FIGS. **2** and **13**, the protection sleeve **370** is radially disposed about a portion of the annular piston cap **280** and the slotted release nut **340**. Fasteners or bolts **353** are configured to threadably couple the protection sleeve **370** to the slotted release nut **340** by passing through the sleeve through bores **382** and engaging the threaded bores **352** of the slotted release nut **340**.

The plurality of threaded bores **352** spaced circumferentially about the central axis **105** of the fourth cylindrical outer surface **351** of the release nut **340** are configured to align with the plurality of circumferentially spaced through holes **382** of the sleeve **370**. The threaded bores **352** are further configured to threadably couple to the fasteners or bolts **353** to secure the sleeve **370** to the release nut **340**.

A seal is disposed in groove **351***a* on the release nut fourth cylindrical outer surface **351** to sealingly engage the third cylindrical inner surface **381** of the protection sleeve **370**. A seal is also disposed in the groove **322***a* on the motor head third cylindrical outer surface **322** to sealingly engage the third inner cylindrical surface **360** of the release nut **340**.

A fifth annular space or cavity **389** is formed radially between the second cylindrical surface **266** of the piston **260** and the second cylindrical inner surface **376** of the sleeve **370**, and axially between the piston cap second end **280***b* and the release nut first end **340***a*. A sixth annular space or cavity **390** is formed radially between the generally cylindrical outer surface **342** of the release nut **340** and the generally cylindrical inner surface **373** of the sleeve **370**. The third, fifth, and sixth cavities **387**, **389**, **390**, respectively, are in fluid communication with one another.

Referring now to FIGS. **14** and **15**, the annular spaces or cavities **385-390** are pressure balanced to resist external pressure and facilitate movement and disconnection of the upper end **200** and lower end **300** of the connection release system **100**. The annular spaces or cavities **385-390** are pressure compensated by means of a pressure compensation system in the plug connector **210**, which has an oil reservoir **395** and bellows system incorporated therein (not shown). The cavities **385-390** are filled via check valves with oil prior to attaching the plug connector **210** at flange **223**. To balance the pressure between the release system **100** upper end **200** and lower end **300**, motor oil is fed via check valves (not shown) to a cavity **391** from a motor cavity **392**. The seals disposed in groove **226***b* (FIGS. **2** and **4**) and groove **287***a* (FIG. **10**) allow the upper and lower ends **200**, **300**, respectively, to separate under high pressure, typically 9,000 to 24,000 psi. By filling the cavities **385-390** with oil, the piston **260** and the release nut **340** are fully enclosed and sealed to exclude sand, silt, and debris, which could cause sticking or jamming and hinder the movement or separation of the upper and lower ends **200**, **300**, respectively.

Referring now to FIGS. **6** and **7**, before activation, the first fluid chamber **248** is filled with hydraulic fluid from the control line or hydraulic fluid source (not shown) and the second fluid chamber **258** is filled with hydraulic fluid. The fluid in the first fluid chamber **248** is connected to fluid source (not shown) and separated from the fluid in the second fluid chamber **258** by the piston **260**. In particular, the hydraulic fluid in the first fluid chamber **248** acts on the piston **260** at the second protrusion **264***b* (FIGS. **9** and **2**), whereas the fluid in the second fluid chamber **258** acts oppositely on the piston at the first protrusion **264***a* such that the piston **260** is pressure-balanced. Thus, the fluid in the first fluid chamber **248** and the fluid in the second fluid chamber **258** act in opposite directions on the piston **260** to keep the piston **260** pressure-balanced. The sealed opening or burst disc **246** in housing **230** acts as a barrier to keep the hydraulic fluid in the second channel **244** out of the second chamber **242**, the plurality of connecting galleries **257**, and the plurality of overflow cavities **255**. The cavities **255** also provide structural strength for the annular piston **260** to resist the collapse pressure from the external environment, which is approximately 24,000 psi. The volume of the cavities **255** is configured to receive the displacement volume of the fluid from the piston **260** to stroke through its actuation length L (FIG. **15**) upon actuation of the release system **100**. Thus, overflow cavities **255** may also be referred to as buffer cavities or buffer chambers.

To actuate the release system **100**, hydraulic fluid is pressurized in the control line (not shown) and fed through inlet port **247** and added to the fluid already in the housing first cylindrical chamber **241** and the housing first elongate channel **243**, which is in fluid communication with the graduated downward-facing shoulder **239** and face **264***c* of the second annular piston protrusion **264***b*. The additional pressurized fluid acts on the second protrusion **264***b* of the piston **260** to move the annular piston **260** axially toward the plug connector **210** while the first annular protrusion **264***a* transfers pressure along second elongate channel **244** to the burst disc **246**. The burst disc **246** is isolated from the pressure compensation fluid and, therefore, independent of the external pressure around the tool or motor. The burst disc is configured to rupture under a desired or predetermined pressure, for example, between 6,000-15,000 psi; factors that impact the rupture pressure include, but are not limited to, the application and the disc rating. As the piston **260** moves axially toward the plug connector **210** and the burst disk **246** ruptures, the hydraulic fluid flows into the second chamber **242** and into the cavities **255** through the connecting galleries **257**. While the piston **260** moves axially toward the plug connector **210**, the slotted release nut fingers **366** also move radially outward to allow the piston threads **268** to disengage the slotted release nut threads **355**. As the piston threads **268** disengage the slotted release nut threads **355**, a hydraulic signature is created that can be used to assess the success of the disconnection as the pressure will build and then fall when each thread disengages. Once the final thread is cleared, as shown in FIG. **15**, the plug connector **210** can be separated from the motor head **310** by pulling the cable or coiled tubing **150** (FIG. **1**).

If the hydraulic line is not functioning for any reason, leakage or damage for example, a secondary release method without the use of a pressurized fluid is available by manually pulling on the cable or coiled tubing **150** to disengage the piston threads **268** from the slotted release nut threads **355**, which is configured to release at a predetermined load, for example, approximately 24,000 lb.

While various embodiments have been shown and described, modifications thereof can be made by one skilled in the art without departing from the scope or teachings herein. The embodiments described herein are exemplary only and are not limiting. Many variations and modifications

of the systems, apparatus, and processes described herein are possible and are within the scope of the disclosure. For example, the relative dimensions of various parts, the materials from which the various parts are made, and other parameters can be varied. Accordingly, the scope of protection is not limited to the embodiments described herein, but is only limited by the claims that follow, the scope of which shall include all equivalents of the subject matter of the claims. Unless expressly stated otherwise, the steps in a method claim may be performed in any order, and disclosed features and components can be arranged in any suitable combination to achieve desired results.

What is claimed is:

1. A tool connection release system, the system comprising:

a housing having a first portion and a second portion;

a piston disposed at least partially within the housing first portion and at least partially within the housing second portion;

a first fluid chamber including a first pressurized fluid acting against the piston;

a fluid source coupled to the first fluid chamber;

a sealed opening configured to rupture and open under a predetermined pressure; and

a second fluid chamber, in fluid communication with the sealed opening, including a second pressurized fluid acting against the piston to oppose the first pressurized fluid and pressure-balance the piston;

wherein addition of a fluid from the fluid source to the first fluid chamber causes the piston to move and the first housing portion to separate from the second housing portion.

2. The system of claim **1**, further comprising a piston shoulder separating the first and second fluid chambers, and wherein the first pressurized fluid in the first fluid chamber acts on the piston shoulder in a first direction, and the second pressurized fluid in the second fluid chamber acts on the piston shoulder in a second direction opposite the first direction.

3. The system of claim **2**, wherein the addition of the pressurized fluid to the first fluid chamber ruptures the sealed opening allowing the fluid to communicate with at least one of a plurality of buffer chambers.

4. The system of claim **3**, wherein the fluid flows past the ruptured sealed opening to the plurality of buffer chambers.

5. The system of claim **4**, wherein the buffer chambers are configured to receive an amount of the fluid equivalent to a displacement volume of the fluid from a stroke of the piston through an actuation length.

6. The system of claim **5**, wherein the first housing portion and the second housing portion are separated by manually pulling on one of the first or second housing portions.

7. A tool connection release system, the system comprising:

a housing having a first portion and a second portion, the first portion being coupled to a cable;

a piston having a first end axially disposed at least partially within the housing first portion, and a plurality of threads at a second end;

a first fluid chamber including a first pressurized fluid acting against the piston;

a fluid source coupled to the first fluid chamber;

a sealed opening configured to rupture and open under a predetermined pressure; and

a second fluid chamber, in fluid communication with the sealed opening, including a second pressurized fluid acting against the piston to oppose the first pressurized fluid and pressure-balance the piston; and

a release nut disposed within the housing second portion and having a plurality of threads at an interior portion of a first end, a recess at an exterior portion of the first end, a second end, and a plurality of circumferentially disposed slots that pass through the plurality of threads and the recess in the first end, the second end being attached to a portion of the housing second end;

wherein the threaded exterior portion of the piston is configured to releasably engage the threaded interior portion of the release nut and the plurality of circumferentially disposed slots is configured to allow the release nut first end to move radially outward and disengage the threaded exterior portion of the piston from the threaded interior portion of the release nut such that the piston and the housing first portion are separable from the release nut and the housing second portion.

8. The tool connection release system of claim **7**, wherein a plurality of cavities are formed between the housing first and second portions and the piston, and between the housing second portion and the release nut, the plurality of cavities being in fluid communication with one another.

9. The tool connection release system of claim **8**, the housing first portion further comprises at least one bore having a burst disc disposed therein.

10. The tool connection release system of claim **9**, wherein the plurality of cavities is filled with fluid, providing a sealed environment for the piston and the release nut.

11. The tool connection release system of claim **10**, the housing first portion further comprising:

a first fluid chamber disposed in the first housing portion, connected to a fluid source, and in fluid communication with a first portion of the piston; and

a second fluid chamber disposed in the first housing portion and in fluid communication with a second portion of the piston;

wherein the first and second fluid chambers are separated by the piston and configured to receive fluid;

wherein when the first fluid chamber and second fluid chamber are filled with fluid, the fluid in the first fluid chamber acts on the piston in a first direction and the fluid in the second chamber acts on the piston in a second direction opposite the first direction to pressure-balance the piston.

12. The tool connection release system of claim **11**, wherein additional fluid is added to the fluid-filled first fluid chamber to displace the fluid and move the piston, such that fluid flows to the burst disc, actuates the burst disc, and flows into a gallery beyond the burst disc;

the movement of the piston thereby causing the threaded exterior portion of the piston to disengage the threaded interior portion of the release nut.

13. The tool connection release system of claim **12**, wherein a hydraulic signature is created as each thread of the threaded exterior portion of the piston disengages each thread of the threaded interior portion of the release nut.

14. The tool connection release system of claim **13**, further comprising a biasing element disposed in the recess at the exterior portion of the release nut first end.

15. The tool connection release system of claim **14**, wherein a force exerted to separate the piston and the housing first portion from the release nut and the housing second portion overcomes the biasing element.

16. The tool connection release system of claim 15, wherein the force exerted to overcome the biasing element is supplied by the additional fluid.

17. The tool connection release system of claim 15, wherein the force exerted to overcome the biasing element is supplied by an external force exerted on the cable and transmitted to the housing first portion and the piston.

18. A tool connection release system, the system comprising:

a plug connector having a first end and a second end, the first end coupled to a cable, and an outer portion of the second end having at least one axial protrusion;

an actuation cylinder housing having a first end, a second end, and a plurality of circumferentially spaced galleries, the first end coupled to the plug connector;

a piston having a first end, a second end, and a plurality of threads at an exterior portion of the second end, the piston being axially disposed at least partially within the activation cylinder housing and forming a first cavity therein;

a piston cap is disposed around the piston and forms a second cavity therein, threadably engages the second end of the actuation cylinder, and is configured to retain the first end of the piston within the actuation cylinder;

a motor head having a first end and a second end, an inner portion of the first end having at least one axial recess configured to engage the protrusion on the outer portion of the plug connector second end;

a release nut having a plurality of threads at an interior portion of a first end, a recess at an exterior portion of the first end, a second end, and a biasing member disposed in the recess; and

a protection sleeve disposed about the release nut and a portion of the piston cap, the sleeve forming a third cavity with the release nut;

wherein the piston is configured to axially slide around an outer portion of the motor head;

wherein the plurality of threads on the exterior portion of the piston second end is configured to releasably engage the threads on the interior portion of the release nut first end upon addition of a pressurized fluid.

19. The system of claim 18, wherein the first, second, and third cavities are filled with fluid and pressure-balanced.

20. The system of claim 19, wherein the addition of the pressurized fluid ruptures a burst disc allowing fluid to communicate with the plurality of galleries.

21. The system of claim 20, wherein the housing first end and the housing second end are separated by manually pulling on one of the first or second housing ends.

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